IS 11285 (2002): Various Tests on Raw Materials to be Used for Coal Based Rotary Kiln Direct Reduction [MTD 30: Sponge Iron and Smelting Reduction]

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भारतीय मानक

कोयला आधारित घूर्ण भट्टी में प्रत्यक्ष अपचयन के दौरान प्रयुक्त होने वाले कच्चे माल के विभिन्न परीक्षण

(पहला पुनरीक्षण)

Indian Standard

VARIOUS TESTS ON RAW MATERIAL TO BE USED FOR COAL BASED ROTARY KILN DIRECT REDUCTION

(First Revision)

ICS 73.040; 77.080.10

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

February 2002

Price Group 2

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Sponge Iron and Smelting Reduction Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was earlier published in 1985. In this revision, various tests on dolomite/limestone have been incorporated. Apart from this other parameters like size distribution and caking index for reductant coal have also been included.

The testing of raw materials for coal based direct reduction in rotary kiln process assumes great importance owing to the sensitivity of the manufacturing process to the raw material characteristics. In addition to the testing for rate of reduction, disintegration and sticking behaviour for the oxide feed stock, reactivity and ash softening characteristics of the reductant, the testing of a combination of ore and coal is of significance.

The Composition of the Committee responsible for formulation of this standard is given in Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

VARIOUS TESTS ON RAW MATERIAL TO BE USED FOR COAL BASED ROTARY KILN DIRECT REDUCTION

(First Revision)

1 SCOPE

This standard covers the tests of raw materials for coal based direct reduction processes in rotary kilns, to produce sponge iron for use in steel making furnaces and in foundaries.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
1350 (Part 2) : 1970	Methods of test for coal and coke (in various parts) Determination of calorific value (*first revision*)
1353 : 1993	Methods of tests for coal carbonization-caking index, swelling number and (LT) gray-king assay (*first revision*)
1354 : 1992	Methods of test for coke-special test (*second revision*)
1493 : 1959	Methods of chemical analysis of iron ores
1493 (Part1) : 1981	Methods of chemical analysis of iron ores: Part 1 Determination of common constituents
1607 : 1977	Methods for test sieving (*first revision*)
1760 (Part 1) : 1991	Methods of chemical analysis of limestone, dolomite and allied materials: Determination of loss on ignition (*first revision*)
(Part 2) : 1991	Determination of silica (*first revision*)
(Part 3) : 1992	Determination of iron oxide, alumina, calcium oxide and magnesia (*first revision*)
5842 : 1986	Method for measuring bulk density of iron oxides lump ores, sinter and pellets (*first revision*)
6495 : 1984	Method of tumbler test for iron oxides, lump ores sinter and pellets (*first revision*)
8167 : 1989	Method for determination of reducibility index of iron ore oxides, lump ore, sinter and pellets (*first revision*)
8624 : 1995	Method for determination of swelling index of iron ore pellets (*first revision*)
9963 : 1981	Determination of shatter index of iron ore, lumps sinter and pellets
10823 : 1994	Method for determination of thermal degradation index (TDI) and reduction degradation index (RDI) of iron oxides; lump ore sinter and pellets (*first revision*)
11283 : 1985	Determination of softening point of iron oxides (in powder form) : lump, ore, sinter and pellets
11284 : 1985	Rotary tube test for iron bearing materials for the manufacture of sponge iron/direct reduced iron (DRI)
11795 : 1996	Guidelines for ash softening studies on solid reductants for direct reduction (*first revision*)
12381 : 1994	Methods of determination of coal (char) reactivity for direct reduction processes (*first revision*)

3 TEST METHODS

3.1 For Oxide Feed Stock (Iron Oxides : Lump Ore, Pellets, Mill Scale, Etc)

3.1.1 *Size Distribution*

3.1.1.1 The size of the oxide feed in the form of lump ore should be fixed for this particular test.

3.1.1.2 The size distribution of the sample of iron oxide when determined in accordance with the methods given in IS 1607 shall be as follows:

– 20 + 15 mm	16-18 percent
– 15 + 10 mm	28-30 percent
– 10 + 8 mm	35-40 percent
– 8 + 5 mm	12-15 percent

For other sizes, the exact figures shall be noted and reported in the results.

3.1.2 *Chemical Analysis*

The chemical analysis of the oxide feed stock shall be determined for moisture, total iron, Fe_2O_3, FeO, sulphur, phosphorus, SiO_2, Al_2O_3, CaO, MgO and loss on ignition.

The chemical analysis of the oxide feed stock for the above constituents shall be determined by the methods specified in IS 1493 and IS 1493 (Part 1) or by any other established instrumental methods (for example, instrumental methods employing X-ray fluorescence technique).

3.1.3 *Physical Testing*

The physical testing of the oxide feed stock is done for the bulk density, angle of repose, size distribution, shatter index, tumbler index and swelling index.

3.1.3.1 The bulk density of samples shall be determined according to IS 5842.

3.1.3.2 The angle of repose of samples shall be determined according to the method mutually agreed.

3.1.3.3 The shatter index of the samples shall be determined according to IS 9963.

3.1.3.4 The tumbler index of the samples shall be determined according to IS 6495

3.1.3.5 The swelling index of the samples shall be determined according to IS 8624.

3.1.4 *Other Tests*

3.1.4.1 Thermal degradation, reducibility and decrepitation tests under static conditions and rotary tube tests are conducted on the oxide feed stock to assess the suitability for direct reduction in rotary kilns.

3.1.4.2 The thermal degradation test for the determination of the thermal degradation index (TDI) and reduction degradation index (RDI) shall be determined as per IS 10823.

3.1.4.3 The reducibility and the decrepitation tests under static conditions are carried out as per the procedure outlined in IS 8167.

3.1.4.4 Rotary tube tests are conducted for assessing the suitability of combination of oxide feed stock and the reductant to determine the reducibility index and the decrepitation behaviour. The rotary tube tests are conducted as per procedure outlined in IS 11284.

3.1.4.5 Softening point of iron oxide for lump ore will be determined by this procedure laid down in IS 11283.

3.2 For Reductant Coal

3.2.1 *Size Distribution*

The size distribution of the sample of coal when determined in accordance with the methods given in IS 1607 shall be as follows:

– 20 + 15 mm	:	10-15 percent
– 15 + 10 mm	:	35-40 percent
– 10 + 5 mm	:	35-40 percent
– 5 mm	:	10-15 percent

3.2.2 *Chemical Analysis*

The proximate analysis of the coal for the determination of moisture, volatile matter, ash, fixed carbon and the ultimate analysis for the determination of carbon, hydrogen, nitrogen, oxygen and sulphur and the chemical analysis of ash for the determination of SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O are carried out.

The chemical analysis of the coal samples shall be carried out according to the procedures given in various parts of IS 1350 (for example, instrumental method employing X-ray fluorescence technique).

3.2.3 *Physical Testing*

3.2.3.1 *Calorific value*

The gross calorific value and the net calorific value are determined for the coal samples according to the procedure prescribed in IS 1350 (Part 2).

3.2.3.2 *Bulk Density*

The bulk density of coal samples shall be determined by the procedure laid down in IS 1354.

3.2.3.3 *Angle of Repose*

The angle of repose of the coal samples shall be determined as per the method mutually agreed (for example, instrumental method employing X-ray fluorescence technique).

3.2.3.4 Caking index, swelling shall be determined by the procedure laid down in IS 1353.

3.2.4 *Other Tests*

3.2.4.1 *Melting characteristics of reductant ash*

The softening point, the melting point and the flow point of the ash in coal under reducing conditions play important role in the temperature profile for the reduction in the kiln. These characteristics shall be determined as per the procedure laid down in IS 11795.

3.2.4.2 *Reactivity of reductant*

The reactivity of the reductant coal is defined as the generation of carbon monoxide per unit weight of the reductant per unit time at the given experimental conditions. The reactivity of the coal shall be determined as per the methods given in IS 12381.

3.3 For Dolomite/Limestone

3.3.1 *Size Analysis*

The size distribution of the dolomite/lime stone shall be as follows:

+ 6 mm	=	5.0 percent, *Max*
– 6 + 1 mm	=	90 percent
– 1 mm	=	5.0 percent, *Max*

3.3.2 Chemical analysis of dolomite shall be determined for loss on ignition, CaO, MgO, Fe_2O_3, SiO_2, Al_2O_3.

3.3.2.1 Loss on ignition of dolomite and lime stone shall be carried out as per the procedure outlined in IS 1760 (Part 1).

3.3.2.2 Silica shall be determined as per the procedure outlined in IS 1760 (Part 2).

3.3.2.3 CaO, MgO, Fe_2O_3 and Al_2O_3 shall be carried out as per the procedure outlined in IS 1760 (Part 3).

3.3.2.4 Size distribution of sample coal when determined may be as follows:

+ 15 – 20 mm	= 10 percent
– 15 + 10 mm	= 30-40 percent
+ 5 – 10 mm	= 30-40 percent
– 5 + 10 mm	= less than 10 percent

ANNEX A

(Foreword)

COMMITTEE COMPOSITION

Sponge Iron and Smelting Reduction Sectional Committee, MTD 30

Organization	*Representative(s)*
Tata Iron & Steel Co Ltd, Jamshedpur	DR AMIT CHATTERJEE (***Chairman***)
Mukund Ltd, Thane	SHRI C. H. SHARMA SHRI A. CHATTERJEE (*Alternate*)
M. N. Dastur & Co (P) Ltd, Kolkata	SHRI ADHIP SENGUPTA MS ADITI TARAFDAR (*Alternate*)
National Metallurgical Laboratory, Jamshedpur	DR SWATANTRA PRAKASH
Kudermukh Iron Ore Co Ltd, Chikmaglur	SHRI T. R. RAO
Sponge Iron India Ltd, Khammam (AP)	SHRI M. AMARESHWAR RAO
SAIL, R&D Centre, Ranchi	SHRI G. I. S. CHAUHAN DR K. K. PRASAD (*Alternate*)
Central Fuel Research Institute, Dhanbad	REPRESENTATIVE
MECON (India) Ltd, Ranchi	SHRI P. BHATTACHARYA SHRI A.K. AGRAWAL (*Alternate*)
Orissa Sponge Iron Ltd, Distt Keonjhor	SHRI N. K. PATNAIK SHRI S. C. JENA (*Alternate*)
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Nova Iron & Steel Co Ltd, Bilaspur	SHRI A. RAJASEKARAN SHRI B. GOPICHAND (*Alternate*)
Prakash Industries, New Delhi	REPRESENTATIVE
Raipur Alloys, Raipur	SHRI N. RATH
Ispat Industries Ltd (Nippo Denro), Raigad	SHRI V. V. JAMNIS SHRI A. K. SAXENA (*Alternate*)
Monnet Ispat Ltd, Raipur	SHRI B. L. VERMA
Usha (India) Ltd, New Delhi	SHRI B. K. ROY
Sponge Iron Manufacturers' Association, New Delhi	SHRI S. S. BHATNAGAR
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Member-Secretary
SHRI RAM AWADH RAM
Deputy Director (MTD), BIS

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